Project: **474,** Project title: **Laptev**
Project lead: **Günther Heinemann,** Report period: **2020-01-01 to 2020-12-31**

The project focuses on simulations with the atmospheric climate model COSMO-CLM (CCLM) adapted for the Arctic (Gutjahr et al. 2016, Heinemann 2020) with 15km (C15) and 5km (C05) for the Arctic (C15 being part of Arctic CORDEX). Climate runs with C15 simulations for recent climate and for the end of the 21st century (RCP8.5) are nested in AWI-CM CMIP6 runs using sea ice information from the sea-ice/ocean model FESOM of AWI-CM. Sea ice data are available on a variable grid with a resolution of 10-25km for the Arctic. These runs are evaluated together with the hindcast of C15, which is nested in ERA-Interim/ERA5 data for 1987-2019 and uses sea ice information from microwave satellite data and ice thickness from PIOMAS.

With the granted resources for 2020 most of the planned simulations were possible. C15 runs using AWI-CM CMIP6 sea ice data have been performed for the winter periods 1978-2012 (C20) and 2070-2100 (FC85). In addition, high-resolution simulations with 5km resolution (C05) have been performed for different regions in order to test new turbulence parameterizations and a new sea ice model with subsequent verifications using data of several expeditions. Evaluations have been performed together with other Arctic CORDEX regional climate models for a summer cruise of the Swedish icebreaker Oden (Sedlar et al. 2020) and for the katabatic wind over Greenland in winter/spring (Heinemann 2020).

Fig.1 shows the BIAS and RMSE for temperature profiles of different regional climate models in comparison with radiosondes for the inner Arctic for summer 2014. All models were driven by ERA-Interim data, a second CCLM run was also driven with ERA5 data. CCLM (purple lines) shows only small bias values for the whole troposphere. Also RMSE of CCLM is among the best models. Smallest errors are found for the reanalyses, which is not surprising, since the measurements were assimilated by the reanalyses and there is no influence of topography. The use of ERA5 data (cclm5) leads to slightly larger errors in the lowest 3km compared to cclmi (using ERA-Interim), but an opposite effect occurs for specific humidity (not shown).

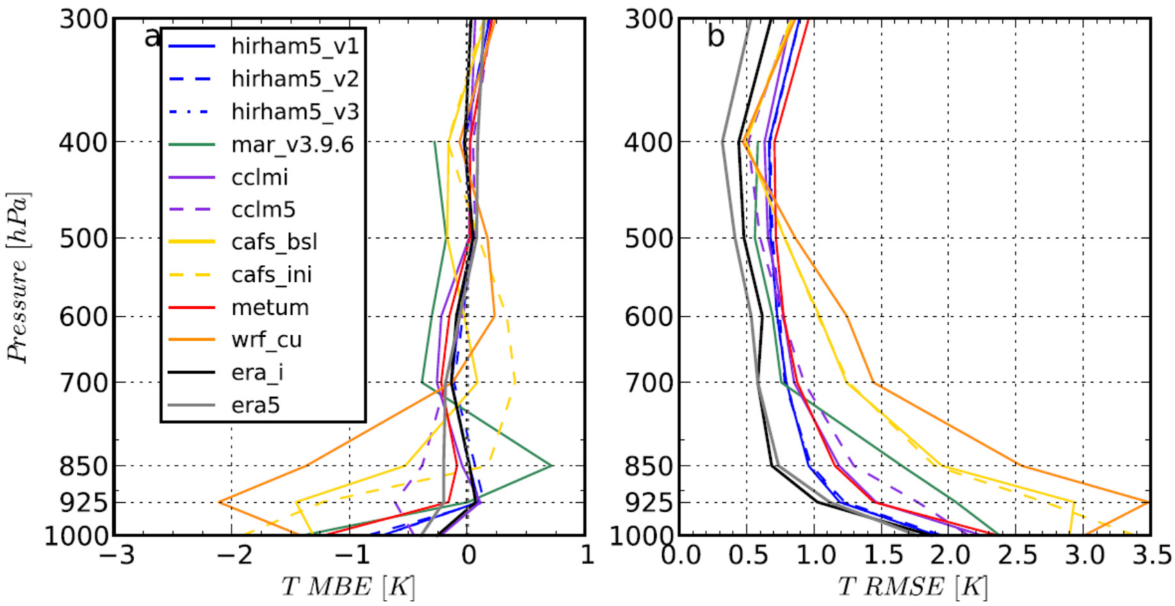

Fig.1: Bias and RMSE for temperature profiles of different regional climate models in comparison with radiosondes for the inner Arctic during summer 2014 (Sedlar et al. 2020).

Only very few observations are available over sea ice areas in winter. An experiment (Transarktika 2019) was performed within the project during April 2019 with a Russian icebreaker drifting in thick ice in the northern Barents Sea. The statistics of the comparison with C05 using an improved sea ice model (version 4.0) is shown in Tab.1. CCLM has a slight cold bias, but overall the comparisons show a very good agreement. The old version (3.1) of the sea ice model has a much larger cold bias (-2.9K). Similar results are found for a study using data of R/V Lance in thin ice in March 2014.

Tab.1: Mean values, bias (CCLM-observation), RMSE and correlation (detrended) based on hourly data for 2m-temperature, 10m-wind, pressure (MSLP), shortwave downward radiation (Kdown), longwave downward radiation (Ldown), and net radiation (Qnet) for April 2019.

	N	OBS	CCLM	Bias	RMS	Corr.
T 2m	674	-13.67	-14.98	-1.31	2.56	0.921
Wind 10m	674	5.54	4.41	-1.13	1.79	0.786
MSLP	674	1013.5	1013.8	0.33	0.94	0.996
Kdown	674	111.11	124.21	13.1	40.28	0.923
Ldown	674	233.38	222.09	-11.3	29.18	0.789
Qnet	674	-2.83	-11.74	-8.91	22.38	0.600

The AWI-CM-simulated sea ice loss and thinning of the ice at the end of the 21st century leads to changes in the sea-ice/ocean interactions as simulated in the climate runs of C15 (with the old sea ice model). Fig.2 shows the histograms of the sensible heat flux distribution for 1978-2012 and 2070-2100 (winter periods Nov-Apr). The histograms are based on monthly means at every ocean grid point of C15 (similar to the satellite-based study of Taylor et al. 2018). For the recent climate, the cases with high ice concentration (80-100%) are most frequent and are associated with both negative (statically stable) and weak positive fluxes. Open water and low sea ice concentration (0-20%) is the second frequent case and the fluxes range from values for the near-neutral boundary layer (zero) to the convective boundary layer (positive) with a peak at 50 W/m² and a long tail with higher values. For 2070-2100, the number of pixels with high ice concentration has decreased by about 60%, and the fraction of open water points has largely increased. The peak in the sensible heat flux values has shift to smaller positive values, reflecting the decreasing atmosphere/ocean interaction due to warmer air temperatures. However, the overall heat input from the ocean surface to the atmosphere gets larger, particularly for specific regions and in the freeze-up season.

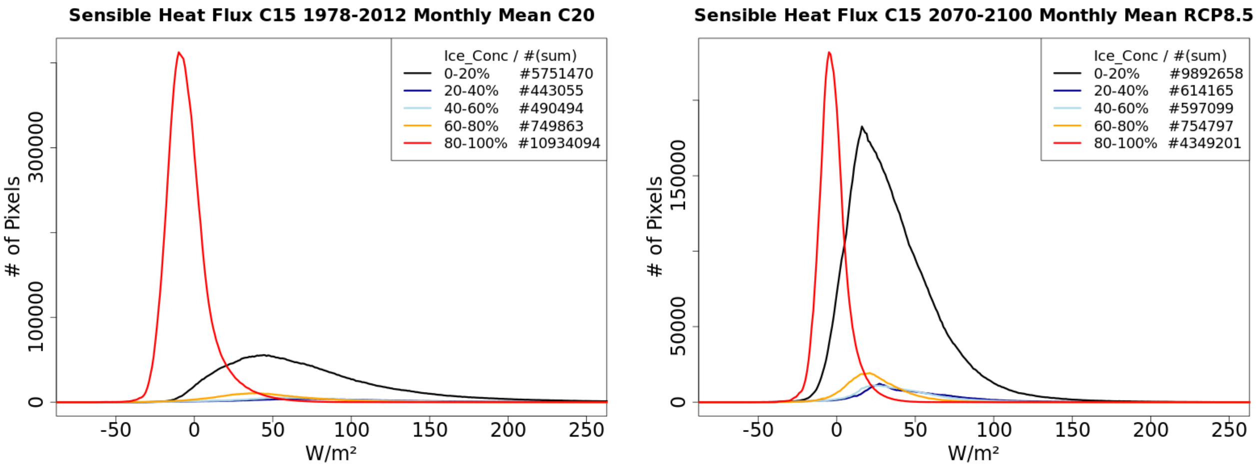

Fig.2: Histograms of the sensible heat flux distribution for winters 1978-2012 (left) and 2070-2100 (right) for different sea ice concentrations.

Literature

Gutjahr, O., Heinemann, G., Preußer, A., Willmes, S., Drüe, C., 2016: Quantification of ice production in Laptev Sea polynyas and its sensitivity to thin-ice parameterizations in a regional climate model. The Cryosphere 10, 2999-3019, doi:10.5194/tc-10-2999-2016.

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